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REQUEST BY CENTRAL REGION FOR PHYTOTOXICOLOGY SOIL SAMPLING OF THE CITY OF TORONTO LESLIE ST. ALLOTMENT GARDENS NOVEMBER 23, 1988

JULY 1990

Ontario
Environment
Environnement
Jim Bradley, Minister/ministre

ISBN 0-7729-7114-5

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ARB-173-89

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PIBS 1051
log 89-2231-173

Background

Between July 5 and September 12, 1988, the Metro Works Department relocated about 10,000 tons of sludge incinerator ash from their collection lagoons to an area adjacent to the public allotment garden plots on the east side of Leslie St. Because of concern expressed in the media regarding the possibility of contamination of the garden soil by ash dust fallout during the relocation process, the Central Region requested that the Phytotoxicology Section sample the soil from garden plots which had been previously sampled.

Phytotoxicology Response

The Phytotoxicology Section had collected soil from four garden plots prior to July 5, at the request of garden plot operators. These were, plots 54 and 151 (sampled May 26), plot 243 (June 8), and plot 69 (July 4). The author re-sampled these plots on November 23, 1988. At this time soil was also collected from two additional plots, number 194, which was closest to the pile of incinerator ash, and plot 203, which was on the opposite side of the allotment garden and therefore farthest from the ash pile.

The samples collected on November 23 were analyzed for total Cu, Ni, Pb, Zn, Ag, As, Cd, Hg, Sb and Se. They were also analyzed for total dioxins (PCDD) and furans (PCDF) (four congener groups each). The pre-ash-relocation samples were not analyzed for Ag, Hg, or the PCDDs/PCDFs.

Results of Inorganic Analysis

Table 1 summarizes the inorganic results from garden plots 54, 69, 151 and 243, sampled before and after the ash was moved. These data do not indicate that the ash has had a significant impact on the soil. Although a few of the elements are slightly higher after the move, there are just as many where the post-move values are marginally lower. There is no consistent trend either between garden plots or among specific elements. When the combined sampling and analytical errors are considered (assuming an average of 10%, which is quite conservative), there is no real difference between the soil concentrations for most of the elements before and after the ash pile was moved. Possible exceptions to this are Cd and Se at plot 69 and Se at plot 151. In these two cases the post-move concentrations for these elements were two to five times the pre-move levels. However, similar Cd and Se concentrations were detected in soil from other garden plots before the move.

Table 2 summarizes the inorganic data from the four plots sampled before the ash move in comparison with the two additional plots sampled after the move. When compared to the plots closest and farthest from the ash pile, Cd is the only element which is consistently elevated relative to both the proximity to the ash pile and the pre/post ash movement sampling (when sampling and analytical errors are considered).

Another indication that the marginal increase in the soil Cd levels may be related to the ash movement (particularly at the plot closest to the ash pile, number 194) is the Pb:Cd ratio.

The mean Pb:Cd ratio of ash samples collected by Central Region on October 21 1988 was approximately 11:1. The Pb:Cd ratio of soil collected from garden plot 194 was 18:1. This ratio was much higher but quite variable at the other plots, ranging from 57:1 to 390:1, with no consistent pattern relative to the distance from the ash pile. However, the mean pre-movement Pb:Cd soil ratio for the common plots was 161:1, compared with 77:1 for the same plots after the ash was moved. The reduction in the Pb:Cd ratio was a result of increases in the Cd levels and not decreases in the Pb levels (all soil Pb levels were similar or marginally greater after the ash move). These data indicate that the relative Cd soil concentration was highest at the plot closest to the ash pile and higher in the garden plots after the ash was moved.

None of the inorganic concentrations exceed the Phytotoxicology Upper Limit of Normal (ULN) guidelines. A ULN guideline does not necessarily imply toxicity. It is the concentration which, quite literally, represents the upper limit of the range of an element in background (non-polluted) soil samples in Ontario. The ULN is calculated from the mean of the available background data plus three standard deviations. Statistically the ULN encompasses 99% of the natural background variation in the province. Separate ULNs are calculated for urban and rural areas. Unfortunately, ULNs are not yet available for all elements either because an insufficient amount of background data is available or the natural variation is so large that the ULN would be unrealistically high. A concentration which exceeds the ULN is a clear indication to the Phytotoxicology investigator that the levels are above normal and a pollution source may be implicated. Although the guideline was not exceeded, plot 194, closest to the ash pile, had a soil Cd level of 3.5 ppm, which is only modestly below the ULN value of 4.0 ppm. The 3 to 4 ppm range in soil is also the lower end at which phytotoxicity symptoms may appear in sensitive plant species.

Results of Dioxin and Furan Analysis

Table 3 summarizes the PCDD and PCDF soil results. These data only refer to post ash-movement. The PCDD and PCDF concentrations of the incinerator ash are also listed in this table (these data were provided to the author by the Central Region May 18, 1989). The highest total PCDD values were detected in the soil from plot 194, which is the closet to the ash pile. Plot number 151, which had the second highest PCDD levels, is also closer to the fence along which the ash has been piled than are the other plots (except number 194). Also, the relative abundance of the PCDD congener groups is similar for the ash and the soil at plot 194, i.e. $P_5CDD < T_4CDD < H_6CDD < H_7CDD < O_8CDD$. These data strongly suggest that the incinerator ash has contributed to the PCDD detected in the soil from the allotment garden plots.

The PCDF soil analysis did not reveal a similar pattern of contamination. Although the closest garden plot had the highest PCDF concentration (plot 194 at 79 ppt), the concentration was only marginally lower at the plot which was farthest from the ash pile (plot 203 at 72 ppt). In addition, PCDFs were not detected in the soil at any of the other garden plots, and where they did occur, they were not present in the same relative congener ratio as the incinerator ash.

The Phytotoxicology Section has a limited amount of soil PCDD data with which to compare these results. Studies to date indicate that PCDDs from one or more of the five

congener groups are found in about 9 out of every 10 urban residential soil samples and about 6 out of every 10 rural soil samples. PCDFs are less widespread, having been detected in about 25% of Ontario soil samples. Soil T_4CDD, P_5CDD, H_6CDD and O_8CDD concentrations similar to those found in the allotment gardens have been detected in Ontario urban residential soil. However, the H_7CDD levels at plot 194 and 151 are three to five times higher than any that have been encountered in Ontario studies to date.

The Centre for Disease Control in Atlanta Georgia has developed a residential soil dioxin cleanup guideline. This guideline is 1 ppb and relates only to 2,3,7,8-T_4CDD. The US EPA uses this guideline as a bench mark in priortizing environmental Superfund remediation sites. By comparison, the highest T_4CDD soil concentration detected at the allotment garden was 61 ppt (0.061 ppb). Assuming all the T_4CDD at this plot was the most toxic 2,3,7,8-T_4CDD isomer (a very unlikely possibility, based on published literature) the level is still only 1/16 of the US guideline. At the national level in Canada, the Canadian Council of Environment Ministers, has proposed a soil guideline of 1 ppb 2,3,7,8-T_4CDD toxic equivalents (TEQ). Table 4 calculates the TEQ value from the total PCDD and PCDF concentrations in the soil from garden plot 194. The TEQ calculates at 0.013, which is approximately 1/76 of the recommended Canadian guideline.

Conclusions

The Phytotoxicology Section was asked by Central Region to sample the soil from the Leslie St Allotment Gardens subsequent to the movement of incinerator ash. Concern was expressed that the ash may have blown over the garden plots and possibly contaminated the soil. Soil was re-sampled from plots which had been sampled prior to the ash movement, and from plots closer to and farthest from the ash pile. In conclusion, it would appear that the movement of incinerator ash has not resulted in a measurable increase in most heavy metals in soil in the allotment garden. Cadmium is a possible exception. The average soil Cd level was almost twice as high after the ash-relocation, relative to pre-relocation concentrations from common sample plots. It was also concluded that the PCDDs originated, in part at least, from the ash pile. However, despite the marginally elevated Cd levels and the presence of PCDDs, none of the existing or the recommended guidelines were exceeded, and therefore there is no reason to restrict the use of the allotment plots for vegetable gardens or the consumption of produce that may be grown.

Table 1: Soil Concentrations of Inorganic Elements at Selected Sites from the Leslie St. Allotment Gardens Before and After the Movement of Incinerator Ash: 1988.

Element	Concentration* Before/After			
	plot 54	plot 69	plot 151	plot 243
Cu	39/39	30/34	21/26	12/13
Ni	16/16	14/17	11/13	9/8
Pb	94/114	78/79	68/73	32/34
Zn	140/133	120/118	100/94	52/52
Ag	NA/0.6	NA/0.4	NA/0.3	NA/0.1
As	5.65/4.40	3.45/3.20	1.90/2.10	2.65/2.37
Cd	1.01/1.13	<0.20/1.1	0.70/0.91	0.50/0.60
Hg	NA/0.09	NA/0.04	NA/0.09	NA/0.05
Sb	0.96/0.80	0.56/0.71	0.50/0.53	0.30/0.29
Se	0.90/1.20	<0.40/1.13	0.43/0.93	1.65/1.40

*All concentrations are ppm, dry weight.
Plots 54 and 151 sampled May 26, 1988.
Plot 243 sampled June 8, 1988.
Plot 69 sampled July 4, 1988.
All plots re-sampled November 23, 1988.
NA - not analyzed

Table 2: The Mean Inorganic Chemical Concentration of Soil Collected from Four Garden Plots Before and After the Incinerator Ash was Moved Compared with Two Additional Plots Sampled November 23, 1988.

Element	Concentration*				
	Mean**		Plot 194	Plot 203	ULN
	Before	After	(closest)	(farthest)	
Cu	26	28	44	30	100
Ni	12	14	17	14	60
Pb	68	75	69	120	500
Zn	103	99	120	117	500
Ag	NA	0.4	0.7	0.1	NE
As	3.41	3.02	2.97	3.07	20
Cd	0.49	0.94	3.50	0.82	4
Hg	NA	0.07	0.09	0.06	0.5
Sb	0.58	0.58	0.53	0.95	8
Se	0.85	1.17	0.90	1.47	2

*All concentrations are ppm dry weight.
** Mean of samples from Plots 54, 69, 151, and 243.
NA - not analyzed.
NE - ULN not established.
ULN - Upper Limit of Normal.
Plot 194 was closest to the incinerator ash pile.
Plot 203 was farthest from the incinerator ash pile.

Table 3: PCDD and PCDF Soil Concentrations in Selected Leslie Street Allotment Garden Plot Samples Collected November 23, 1988. Plots are listed from Left to Right in Relative Increasing Distance from the Ash Pile.

PCDD/F		Garden Plot Number					
	Incinerator Ash	194*	151	54	69	243	203
T_4CDD	420	61	ND	ND	ND	ND	ND
P_5CDD	110	ND	ND	ND	ND	ND	ND
H_6CDD	1300	75	ND	ND	ND	ND	30
H_7CDD	3400	1400	2100	ND	240	ND	860
O_8CDD	9800	1800	1100	950	1000	130	880
Total PCDD	15030	3336	3200	950	1240	130	1770
T_4CDF	2200	ND	ND	ND	ND	ND	ND
P_5CDF	1000	ND	ND	ND	ND	ND	ND
H_6CDF	ND	ND	ND	ND	ND	ND	ND
H_7CDF	170	ND	ND	ND	ND	ND	38
O_8CDF	100	79	ND	ND	ND	ND	34
Total PCDF	3470	79	ND	ND	ND	ND	72

All concentrations are parts per trillion.
Incinerator ash data provided by Central Region.
* plot closest to the ash pile.

Table 4: Calculation of 2,3,7,8-T_4CDD Toxic Equivalents (TEQ) for Soil from Garden Plot 194.

Congener	Soil Conc. in ppb	% of Group 2,3,7,8-subst.	Est. Conc. 2,3,7,8-isom.	TEF	2,3,7,8-TCDD TEQ
T_4CDD	0.061	5	0.003	1	0.003
P_5CDD	ND	15	ND	0.5	ND
H_6CDD	0.075	30	0.011	0.1	0.001
H_7CDD	1.400	50	0.700	0.01	0.007
O_8CDD	1.800	100	1.800	0.001	0.002
T_4CDF	ND	5	ND	0.1	ND
P_5CDF	ND	10	ND	0.5	ND
H_6CDF	ND	25	ND	0.1	ND
H_7CDF	ND	75	ND	0.01	ND
O_8CDF	0.079	100	0.079	0.001	0.00008
TOTAL 2,3,7,8-T_4CDD TOXIC EQUIVALENTS					0.013
RECOMMENDED CANADIAN GUIDELINE (TEQ)					1.0

ND - not detected.
TEF - Toxic Equivalent Factor